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(54) **DUAL DRIVE PLATE DAMPER FOR HYBRID ELECTRIC VEHICLES**

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B60K 6/387	(2007.10)
B60K 6/40	(2007.10)
B60K 6/38	(2007.10)
F16D 1/076	(2006.01)
F16D 3/50	(2006.01)

(52) **U.S. Cl.**

CPC . ***F16D 13/38*** (2013.01); ***B60K 6/26*** (2013.01); ***B60K 6/387*** (2013.01); ***B60K 6/40*** (2013.01); ***F16D 25/0635*** (2013.01); *B60K 6/38* (2013.01); *F16D 1/076* (2013.01); *F16D 3/50* (2013.01)

(58) **Field of Classification Search**

CPC F16D 13/38; F16D 13/76; F16D 25/0635; F16D 25/0638; F16D 1/06; F16D 1/076; B60K 6/38

See application file for complete search history.

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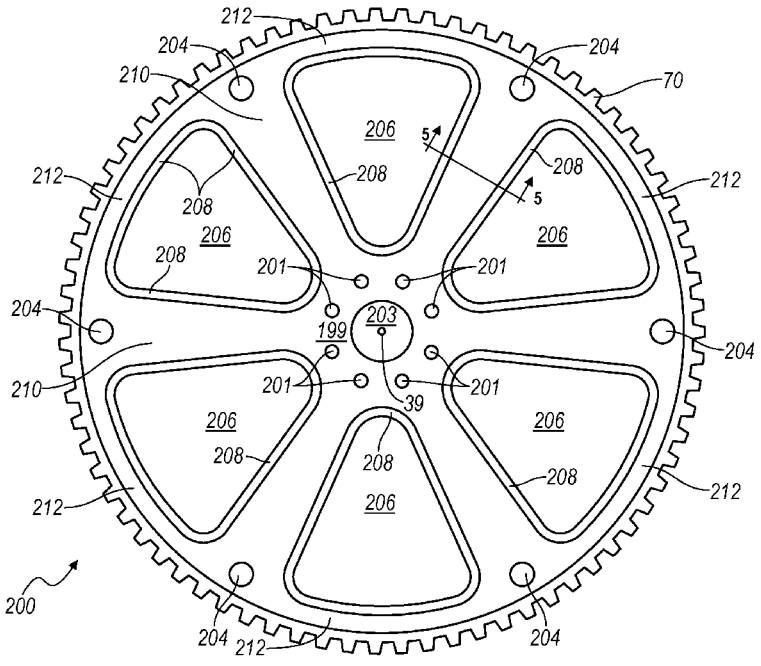
(57) **ABSTRACT**

An assembly includes an engine output concentric with an axis, an input, a starting gear, a first drive plate secured to the engine output, including a rim supporting the starting gear, and arms extending radially outward from the axis, and a second drive plate rotatably secured to the input, and secured to the first drive plate at a location spaced radially outward from the axis.

11 Claims, 5 Drawing Sheets



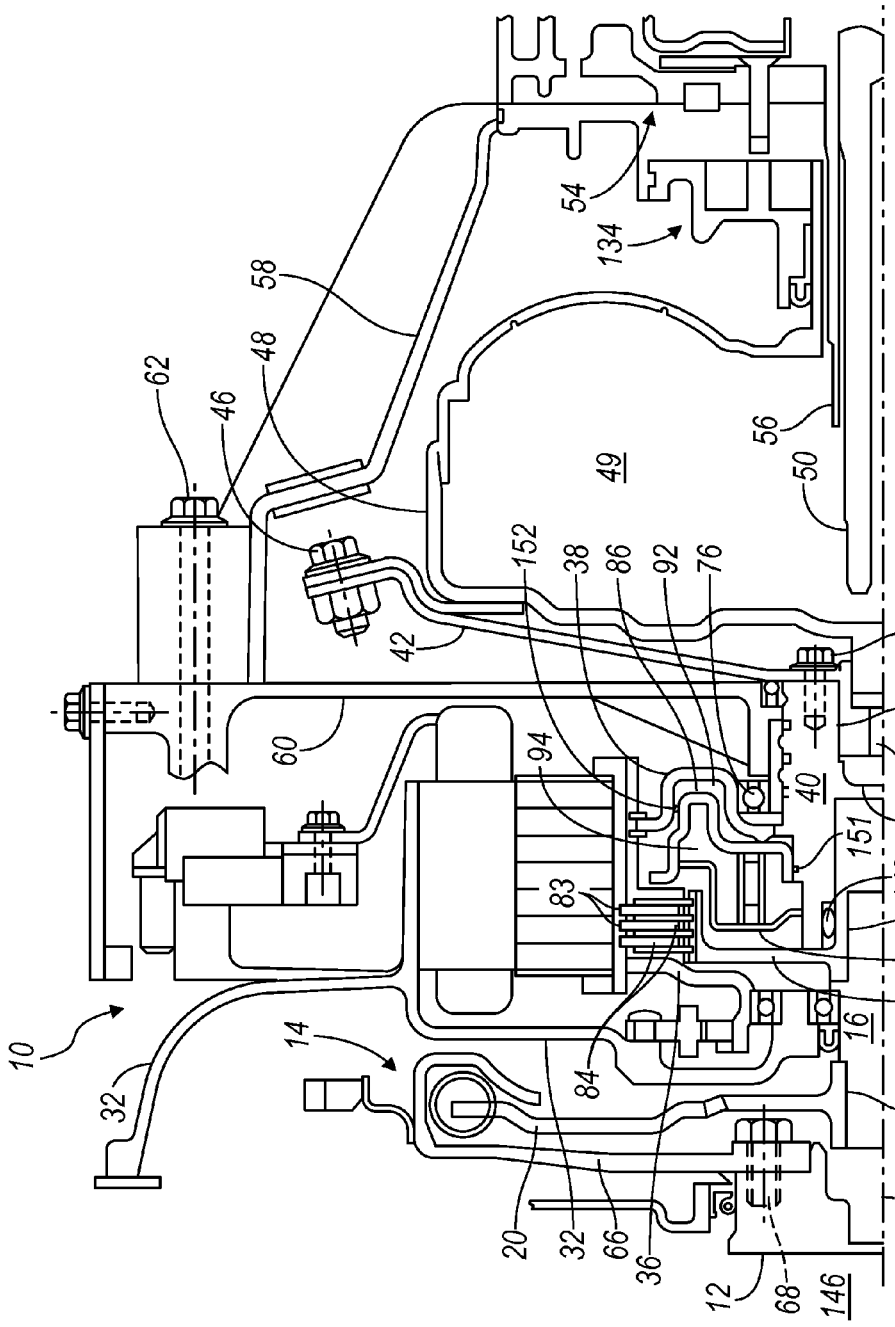

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FIG. 1A

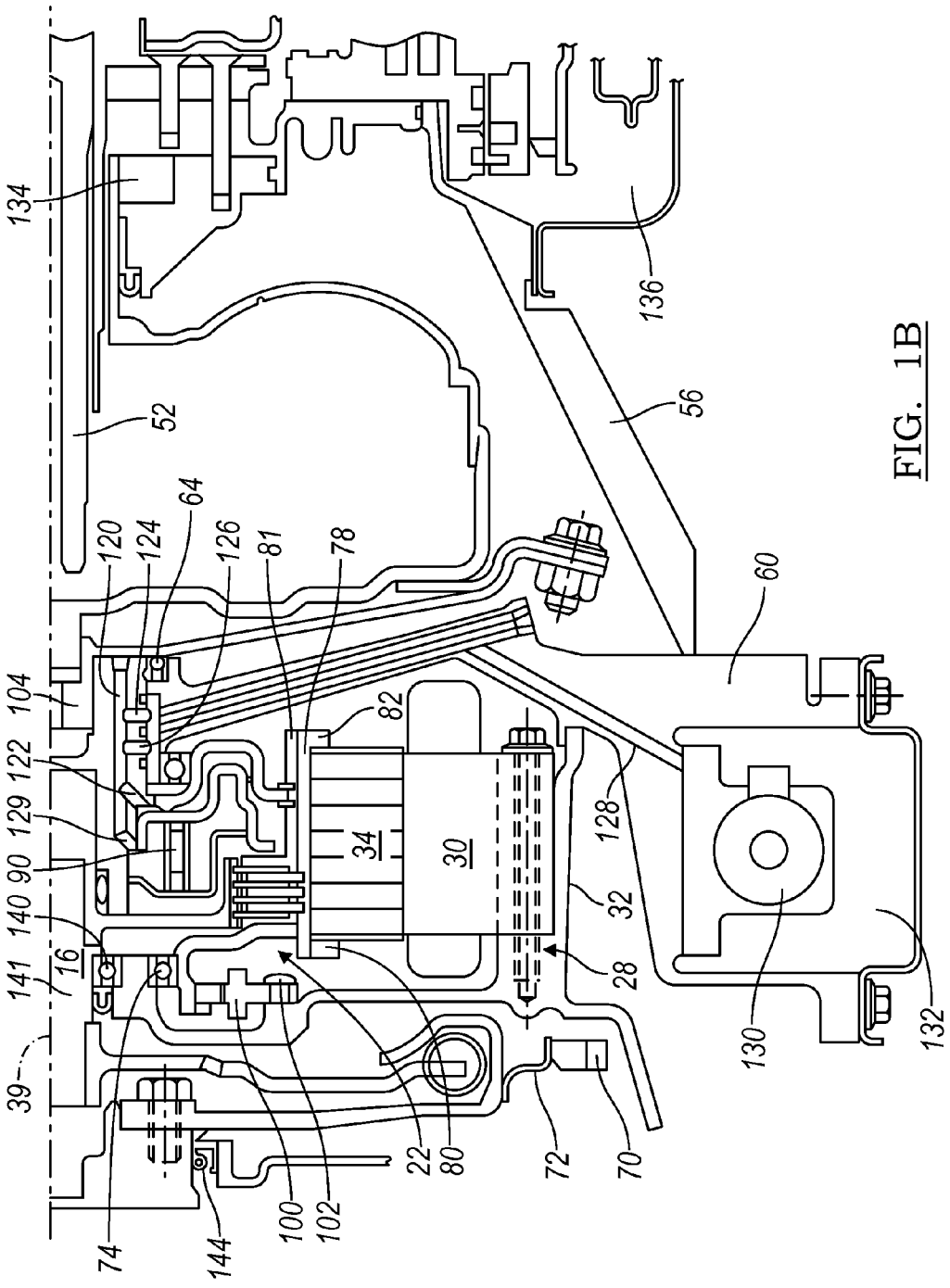
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FIG. 1B

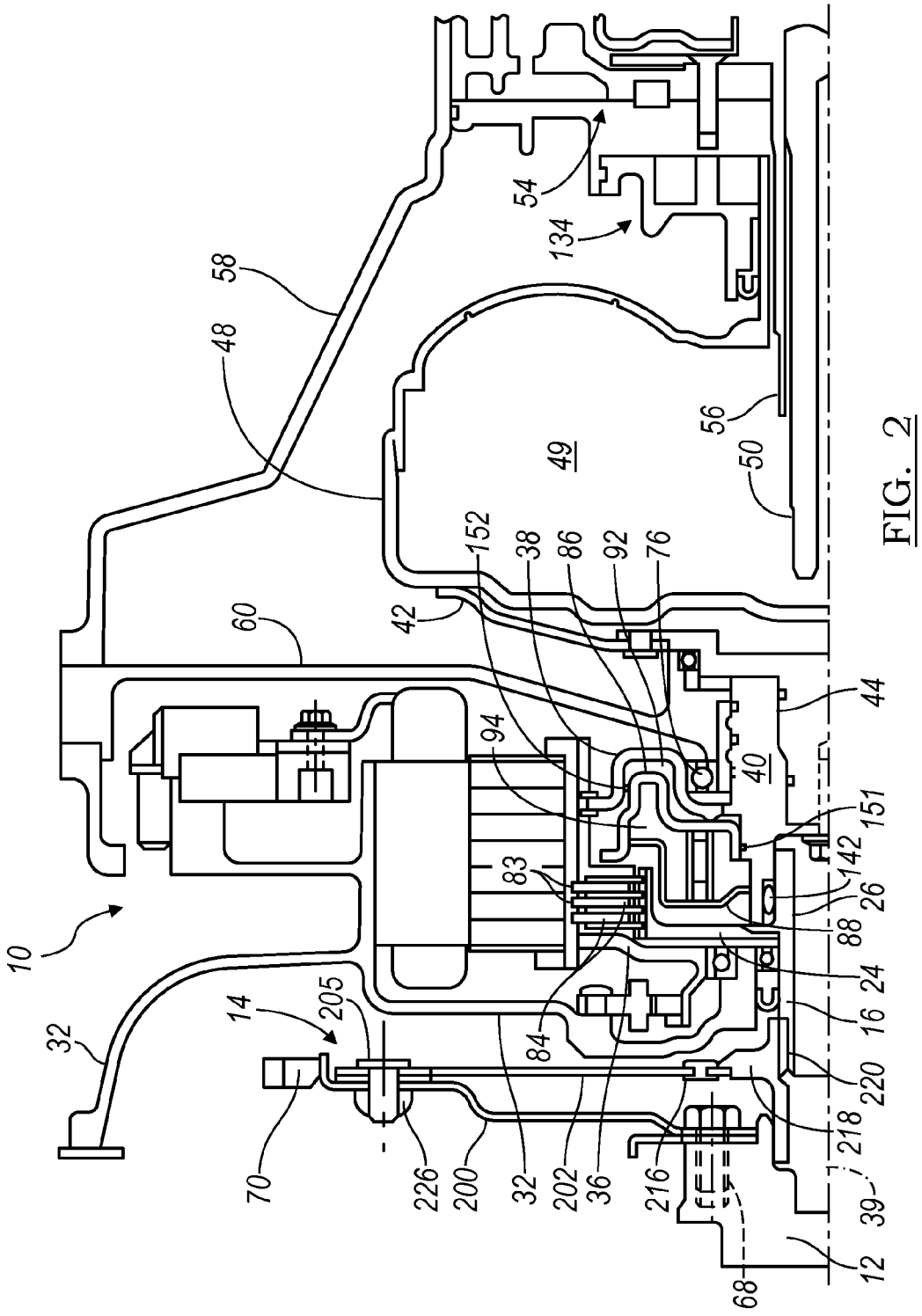
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FIG. 2

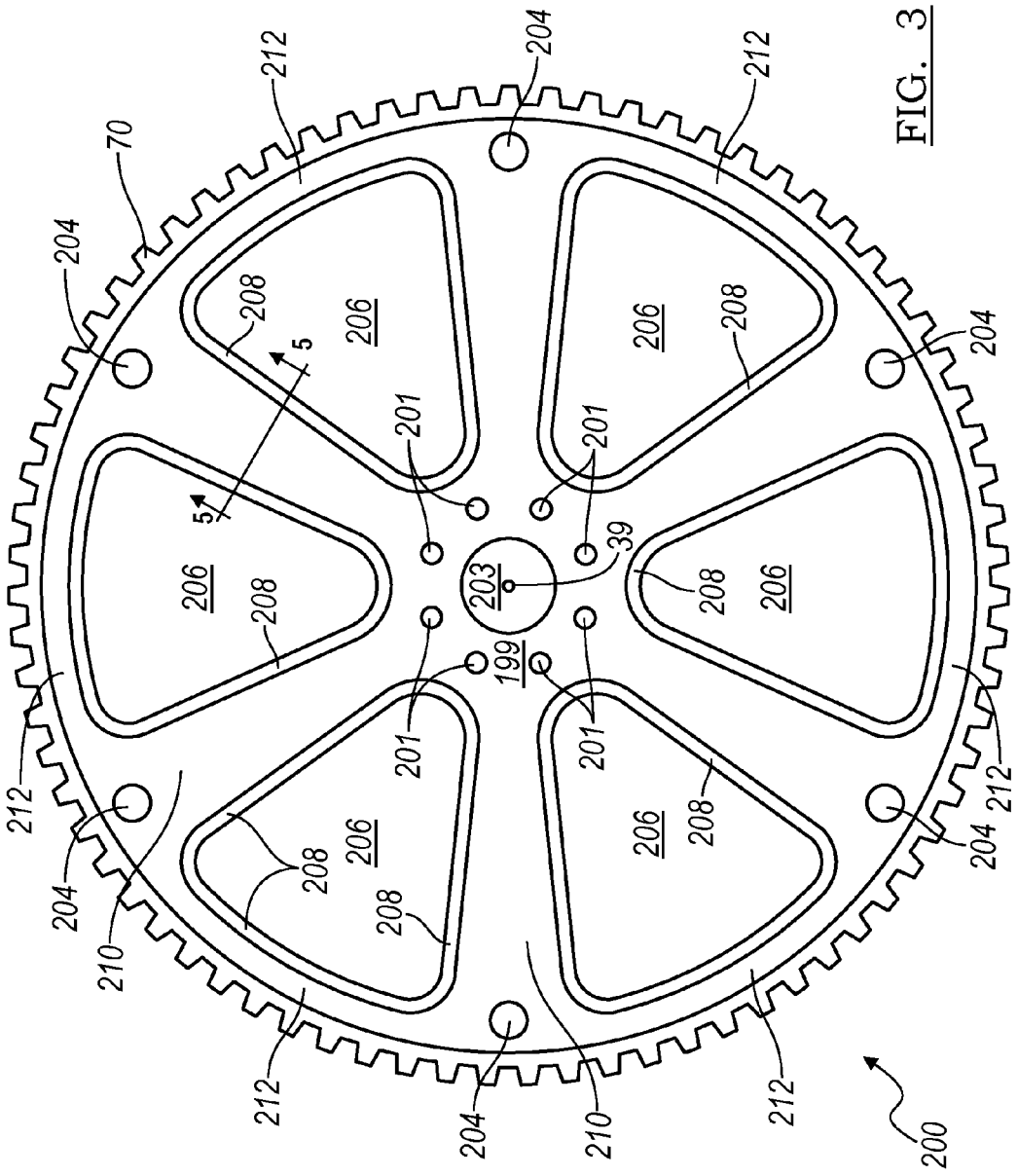

FIG. 3

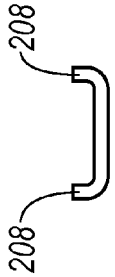

FIG. 5

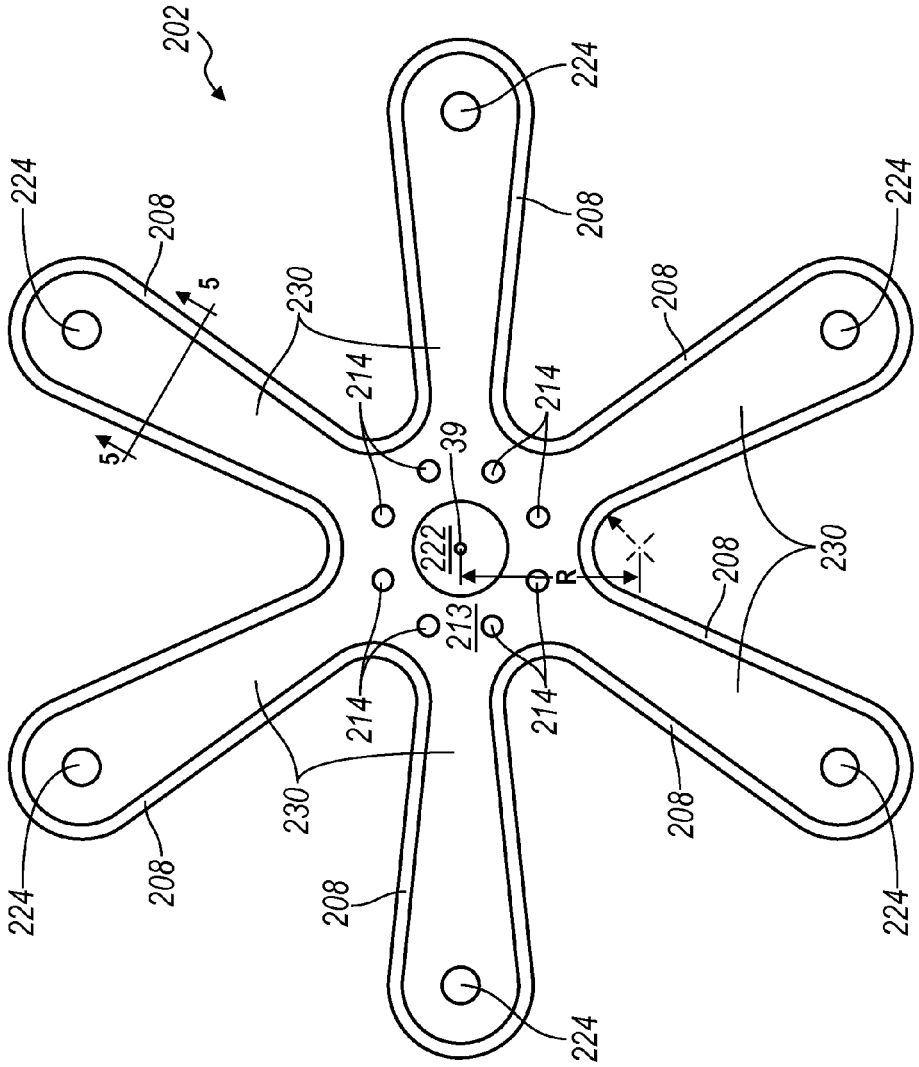

FIG. 4

DUAL DRIVE PLATE DAMPER FOR HYBRID ELECTRIC VEHICLES

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a powertrain of hybrid electric vehicles, particularly to a powertrain module that can be installed between and secured to an engine output and a transmission input.

2. Description of the Prior Art

Hybrid electric vehicles (HEVs) have both an internal combustion engine and an electric machine, which are alternately, or in combination, used to propel the vehicle. A variety of different powertrains are used in hybrid vehicles such as a parallel configuration, in which the engine is connected to the motor by a disconnect clutch with the motor driving a torque converter input of an automatic power transmission. The transmission has an output which is connected to a differential coupled to the two driven wheels of the vehicle.

A need exists in the industry for a hybrid electric powertrain that includes a modular subassembly for use with a variety of engines and transmissions, such that the module can be installed between and secured to an output of one of a number of engines and to an input of one of a number of transmissions. The assembled powertrain may then be employed in a variety of vehicles. The module should include a hydraulically actuated disconnect clutch, the electric machine and suitable power paths between the engine and electric machine to the transmission input. Preferably, the module provides for hydraulic communication from the transmission's hydraulic system to the clutch, a balance dam and the electric machine. The module must provide an oil sump containing hydraulic fluid delivered to the module, and a path for continually returning that fluid to the transmission's oil sump so that the transmission pump is continually supplied reliably with fluid.

The module should require low manufacturing and assembly costs, no vehicle body modification, and reliable performance.

This module is sometimes call a front module (FM), since it is part of the MHT and is bolted in front of the transmission. Since this module is purely a length addition to the base powertrain, it is desired to make the module as short as possible. The connection between the engine and the FM usually has a damper to protect the FM input shaft spline from engine torsional vibrations. The damper adds length and cost of the powertrain.

The damper has a natural frequency that is passed through every time the engine starts and stops. The damper also increases powertrain inertia protentially reducing fuel economy and performance.

SUMMARY OF THE INVENTION

An assembly includes an engine output concentric with an axis, an input, a starting gear, a first drive plate secured to the engine output, including a rim supporting the starting gear, and arms extending radially outward from the axis, and a second drive plate rotatably secured to the input, and secured to the first drive plate at a location spaced radially outward from the axis.

The assembly requires a short axial length, is easy to install on engine crank shaft, and has low production and installation costs.

The mechanical properties, such as flexural and torsional stiffness of the arms and cutouts of the drive plates can be designed to provide compliance and reduce cyclic torque (due to engine cylinder firing events) and load in both torsional directions on downstream components.

The scope of applicability of the preferred embodiment will become apparent from the following detailed description, claims and drawings. It should be understood, that the description and specific examples, although indicating preferred embodiments of the invention, are given by way of illustration only. Various changes and modifications to the described embodiments and examples will become apparent to those skilled in the art.

DESCRIPTION OF THE DRAWINGS

The invention will be more readily understood by reference to the following description, taken with the accompanying drawings, in which:

FIGS. **1**A and **1**B comprise a side cross-sectional view of a powertrain module showing a front connection to an engine output and a rear connection to a transmission torque converter input;

FIG. **2** is a side cross-sectional view of a powertrain of FIGS. **1**A and **1**B showing a dual drive plate damper connected to the engine output and input shaft;

FIG. **3** is a front view of the flex plate that is connected to the engine output;

FIG. **4** is a front view of the flex plate that is connected to the input shaft; and

FIG. **5** is a cross section taken at planes **5**-**5** in FIGS. **3** and **4**.

DESCRIPTION OF THE PREFERRED EMBODIMENT

FIGS. **1**A and **1**B illustrate a module **10** of a powertrain for a hybrid electric vehicle that includes an engine having a rotary output **12**; a torsional damper **14**, secured to the engine output **12**; an input shaft **16**, secured by a spline **18** to an output **20** of damper **14**; a disconnect clutch **22**, supported on a clutch hub **24** that is secured by a spline **26** to input shaft **16**; an electric machine **28**, which includes a stator **30** bolted to a front bulkhead **32** and a rotor **34** supported by a first leg **36** and a second leg **38** for rotation about an axis **39**; a rotor hub **40**, secured preferably by a weld to leg **38**; and a flexplate **42**, secured at one end by a spline connection **44** to rotor hub **40** and secured at the opposite end by bolts **46** to a torque converter casing **48**, which encloses a hydrokinetic torque converter **49**. The electric machine **28** may be an electric motor or an electric motor-generator.

Torque converters suitable for use in the powertrain are disclosed in and described with reference to FIGS. 4a, 4b, 5, 12 and 15 of U.S. patent application Ser. No. 13/325,101, filed Dec. 14, 2011, the entire disclosure of which is herein incorporated by reference.

The torque converter **49** includes a bladed impeller wheel located within and secured to casing **48**; a bladed turbine, driven hydrokinetically by the impeller and secured by a spline **50** to the input shaft **52** of an automatic transmission **54**; and a bladed stator wheel, located between the turbine and stator and secured to a stator shaft **56**, which is held against rotation on a transmission housing **58**.

A rear bulkhead **60**, secured by bolts **62** to the transmission housing **58**, is fitted at its radial inner surface with a hydraulic seal **64**, which contacts the radial outer surface of rotor hub **40**.

A flywheel **66**, secured by bolts **68** to the engine's rotary output **12**, carries an engine starting gear **70**, which is secured by a disc **72**, welded to the starting gear and flywheel.

A bearing **74** supports the first leg **36** for rotation on the front bulkhead **32**. A bearing **76** supports the second leg **38** for rotation on the rotor hub **40**. A tube **78**, aligned with axis **39** and supporting the rotor **34** for rotation about the axis, is secured to the first leg **36** and second leg **38**. Lips **80**, **82** at the front and rear ends, respectively, of tube **78** may be rolled radially outward to secure the rotor **34** to tube **78** and to prevent axial displacement of the rotor **34** relative to the tube. The inner surface of tube **78** is formed with an axial spline **81**, which is engaged by the legs **36**, **38** and alternate plates **83** of the disconnect clutch **22**. The friction plates **84** of clutch **22** are secured by an axial spline formed on the radial outer surface of clutch hub **24**.

A hydraulic servo for actuating clutch **22** includes a piston **86**, balance dam **88**, return spring **90** and hydraulic lines for transmitting actuating pressure to the pressure control volume **92** at the right hand side of piston **86** and to the pressure balance volume **94** at the left hand side of the piston. Piston **86** moves leftward in a cylinder formed by the rear leg **38** when actuating pressure and hydraulic fluid is supplied to volume **92**, by the use of seals **151** and **152**, thereby causing clutch **22** to engage and driveably connect rotor **34** and the engine output **12** through damper **14**, input shaft **16**, clutch hub **24** and clutch **22**.

Because the piston **86**, balance dam **88** and return spring **90** are supported on the rotor hub **40**, rotational inertia of the piston **86**, balance dam **88** and return spring **90** is located on the output side, i.e., the rotor side of clutch **22**.

Rotor **34** is continually driveably connected to the transmission input shaft **52** through the torque path that includes rear leg **38**, rotor hub **40**, flexplate **42**, torque converter casing **48**, the hydrodynamic drive connection between the torque converter impeller and turbine, which is connected by spline **50** to transmission input shaft **52**.

A resolver **100**, a highly accurate type of rotary electrical transformer used for measuring degrees of rotation, is secured by bolts **102** to the front bulkhead **32**, is supported on the front bulkhead **32** and first leg, and is located axially between the front bulkhead **32** and rear bulkhead **60**.

The teeth of spline **44**, which produces a rotary drive connection between flexplate **42** and rotor hub **40**, are fitted together such that no lash is produced when torque is transmitted between the flexplate and rotor hub. Flexplate **42** is formed with a thick walled portion **104** having a threaded hole **106** that terminate at a web **108**. The external spline teeth on flexplate **42** are forced axially into engagement with the internal spline teeth on rotor hub **40** by bolts **110**, which engage threaded holes in the right-hand end of rotor hub **40**. The engaged spline teeth at the spline connection **44** are disengaged upon removing bolts **110** and threading a larger bolt into hole **106** such that the bolt contacts web, thereby forcing flexplate axial rightward.

Rotor hub **40** is formed with multiple axially-directed hydraulic passages **120** and laterally-directed passages **122**, **124**, **126**, **128**, **129**, which carry hydraulic fluid and pressure to module **10** from the hydraulic system of the transmission **54**. Passages **122**, **124**, **126**, **128**, **129** carry hydraulic fluid and pressure which includes to the control volume **92** of the servo of clutch **22** located at the right hand side of piston **86**, to the pressure balance volume **94** between balance dam **88** and the piston, to a variable force solenoid (VFS) **130**, and to the surfaces of rotor **34** and stator **30**, which surfaces are cooled by the fluid. The rear bulkhead **60** is formed with passage **128**, which communicates hydraulically with VFS **130**.

The rear bulkhead **60** supports a sump **132**, which contains fluid supplied to module **10** from the hydraulic system of the transmission **54**. Transmission **54** includes a sump **136**, which contains hydraulic fluid that is supplied by a transmission pump **134** to the transmission hydraulic system, from which fluid and control pressure is supplied to module **10**, torque converter **49**, transmission clutches and brakes, bearings, shafts, gears, etc.

A bearing **140**, fitted in the front bulkhead **32**, and a bearing **142**, fitted in the rotor hub **40**, support input shaft **16** in rotation about axis **39**. The front bulkhead **32** also supports the stator **30** in its proper axial and radial positions relative to the rotor **34**. Bearing **76**, fitted between rear bulkhead **60** and rotor hub **40**, and bearing **142** support rotor hub **40** in rotation about axis **39**. The front and rear bulkheads **32**, **60** together support rotor **34** in rotation about axis **39** due to bearing **74**, fitted in bulkhead **32**, and bearing **76**, fitted in bulkhead **60**.

Seal **64**, fitted in the rear bulkhead **60**, and seal **141**, fitted in the front bulkhead **32**, prevent passage of fluid from module **10** located between the bulkheads **32**, **60**. Another dynamic seal **144** prevents passage of contaminants between the engine crankshaft **146** and module **10**.

The components of module **10** are installed and assembled in the module. The assembled module can then be installed between and connected to the engine output **12** and the torque converter casing **48**.

In operation, when the engine output **12** is driven by an engine, torque is transmitted from the engine through rotor hub **40** and flexplate **42** to the torque converter casing **48**, provided that clutch **22** is engaged. The rotor **34** electric machine **28** is continually driveably connected through tube **78**, leg **38**, rotor hub **40** and flexplate **42** to the torque converter casing **48**. Therefore, the torque converter casing **48** can be driven by the engine alone, provided the electric machine **28** is off and clutch **22** is engaged; by the electric machine alone, provided the engine is off or the engine is operating and the clutch is disengaged; and by both the engine and electric machine concurrently.

FIG. **2** illustrates drive plates **200**, **202** located forward of front bulkhead **32**. FIGS. **2**, **3** and **5** show that drive plate **200** includes a center portion **199** formed with radially inner holes **201**, into each of which holes **201** one of the bolts **68** passes to secure drive plate **200** to the engine's rotary output **12**. Drive plate **200** has a central pilot hole **203** for locating the drive plate on the engine output **12**. Drive plate **200** also has radially outer holes **204**, into each of which holes **204** one of the bolts **205** passes to secure drive plate **200** to drive plate **202**. Drive plate **200** is formed with cutouts **206**, each cutout angularly spaced around axis **39** and separated by a radial arm **210** that extending radially from the center portion **199** to an outer rim **212**, which supports the starting gear **70**. Each radial arm **210** is stiffened by a flange **208** that extends around the periphery of each cutout **206**.

FIGS. **2**, **4** and **5** show that second drive plate **202** includes a central portion **213** formed with radially inner holes **214**, into each of which holes **214** one of the rivets **216** passes to secure drive plate **202** to a hub **218**, which is driveably connected by an interference spline **220** to input shaft **16**. Drive plate **202** has a central pilot hole **222** for locating the drive plate on the hub **218**. Drive plate **202** also has radially outer holes **224**, into each of which holes **224** one of the bolts **205** passes to secure drive plate **200** to drive plate **202**. A nut **226** engaged with the thread of each bolt **205**, completes the outer attachment. Drive plate **202** is formed with radial arms **230** angularly spaced about axis **39** and extending radially from the center portion **213**. Drive plate **202** is stiffened by a flange **208** that extends around its periphery. Dimension R is a func-

tion of the magnitude of torque transmitted by the drive plates **200**, **202** and the material endurance limit.

The two drive plates **200**, **202** couple the engine output **12** to the front module **10**, drive plate **200** attached to the engine crank shaft and drive plate **202** attached to the input shaft **16**. The engine drive plate **200** has the starter ring gear **70** attached.

In accordance with the provisions of the patent statutes, the preferred embodiment has been described. However, it should be noted that the alternate embodiments can be practiced otherwise than as specifically illustrated and described.

The invention claimed is:

1. An assembly, comprising:

an engine output concentric with an axis;

an input;

a first drive plate secured to the engine output, including a rim and arms extending radially outward from the axis;

a second drive plate rotatably secured to the input, secured to the first drive plate at a location spaced radially outward from the axis, including a second center portion and second arms extending radially outward from the axis.

2. The assembly of claim **1**, further comprising a starting gear, and wherein the first drive plate further comprises:

a center portion;

cutouts angularly spaced about the axis, each arm extending between successive cutouts from the center portion toward the rim, the starting gear being connected to the rim.

3. The assembly of claim **2**, further comprising a flange that extends around a periphery of each cutout.

4. The assembly of claim **2**, wherein the center portion is formed with a pilot hole fitted on the engine output.

5. The assembly of claim **1**, further comprising a second flange that extends around a periphery of each second arm.

6. The assembly of claim **1**, further comprising:

a hub rotatably secured by a spline to the input; and

wherein the second center portion is formed with a second pilot hole fitted on the hub.

7. An assembly, comprising:

an engine output concentric with an axis;

an input;

a starting gear;

a first drive plate secured to the engine output, including a rim supporting the starting gear, arms extending radially outward from the axis, a center portion, cutouts angularly spaced about the axis, each arm extending between successive cutouts from the center portion toward the rim, and a flange that extends around a periphery of each cutout;

a second drive plate rotatably secured to the input, and secured to the first drive plate at a location spaced radially outward from the axis.

8. The assembly of claim **7**, wherein the center portion is formed with a pilot hole fitted on the engine output.

9. The assembly of claim **7**, wherein the second drive plate further comprises:

a second center portion;

second arms extending radially outward from the axis.

10. The assembly of claim **9**, further comprising a second flange that extends around a periphery of each second arm.

11. The assembly of claim **9**, further comprising:

a hub rotatably secured by a spline to the input; and

wherein the second center portion is formed with a second pilot hole fitted on the hub.

* * * * *